SM23A-08: Comparison of the Magnetosphere-Ionosphere Responses to Sudden Solar Wind Dynamic Pressure Increase and Decrease

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Solar wind dynamic pressure control on the Magnetosphere System

Sudden increase in solar wind dynamic pressure:

M-I Response:
- Dawn-dusk asymmetry[1]
- Consists of Preliminary + Main Phase[2]
- Magnetospheric vortices at the Main Phase[3]

I-T Response:
- Observations of ion and electron temperature enhancement[4], reproduced with simulations[5]
- Changes in density and composition[5]

Sudden decrease in solar wind dynamic pressure:

M-I Response:
- Dawn-dusk asymmetry[6]
- Consists of **Preliminary**[7] + Main Phase
- Magnetospheric vortices at the Main Phase[8]

I-T Response:
- Observations of electron precipitation[9] at dusk, **reproduced with simulations**[10]
- ➢ **Changes in ion and electron temperature**

- What are the differences between the responses in the M-I system? Can the mirror image scenario explain the perturbations?
- What are the fundamental processes associated with two step response?
- Which magnetospheric and ionospheric conditions contribute to the response of the M-I system?

(1) Araki (1994a;1994b), Planet. Sci. (2) Fujita et al., (2003a;2003b,2004,2005), JGR; Yu and Ridley (2009) Ann. Geo., (2011) JGR (3) Slinker et al., ; Kivelson and Southwood (1991), GRL; Samsanov and Sibeck, (2013), JGR (4) Zou et al., 2017, GRL (5) Schunk et al., (1994), GRL; Ozturk et al., 2018, JGR (6) Araki and Nagano (1988), JGR, Takeuchi et al., (1995); (2002), JGR (7) Fujita et al., 2012, JGR (8) Zhao et al., 2016, JGR (9) Sato et al., (2001), GRL; Belakhovsky et al.,(2016), Geomag. And Aero. (10) Ozturk et al., in review, JGR

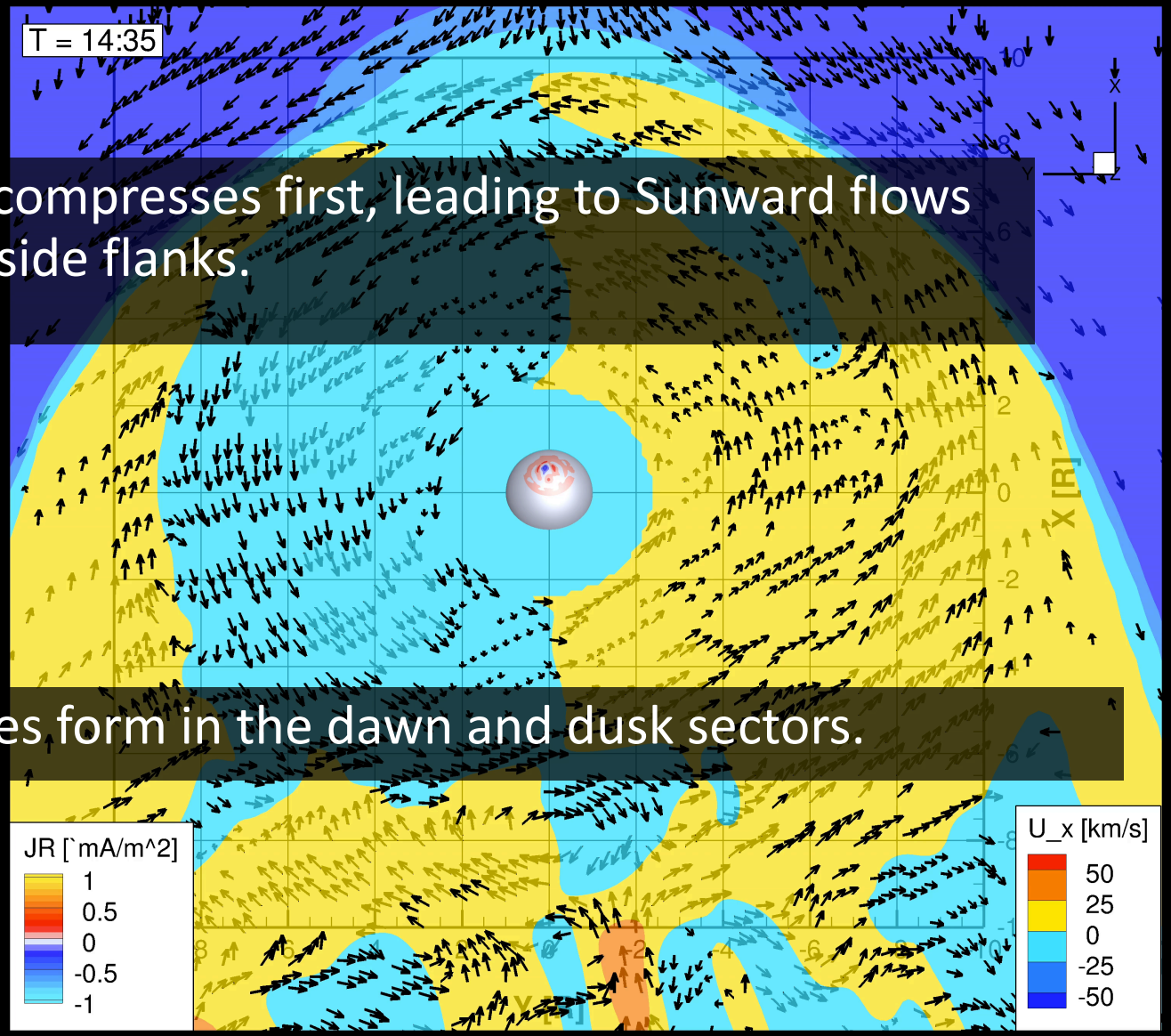
Sudden compression of the magnetosphere: 1. Preliminary Perturbation

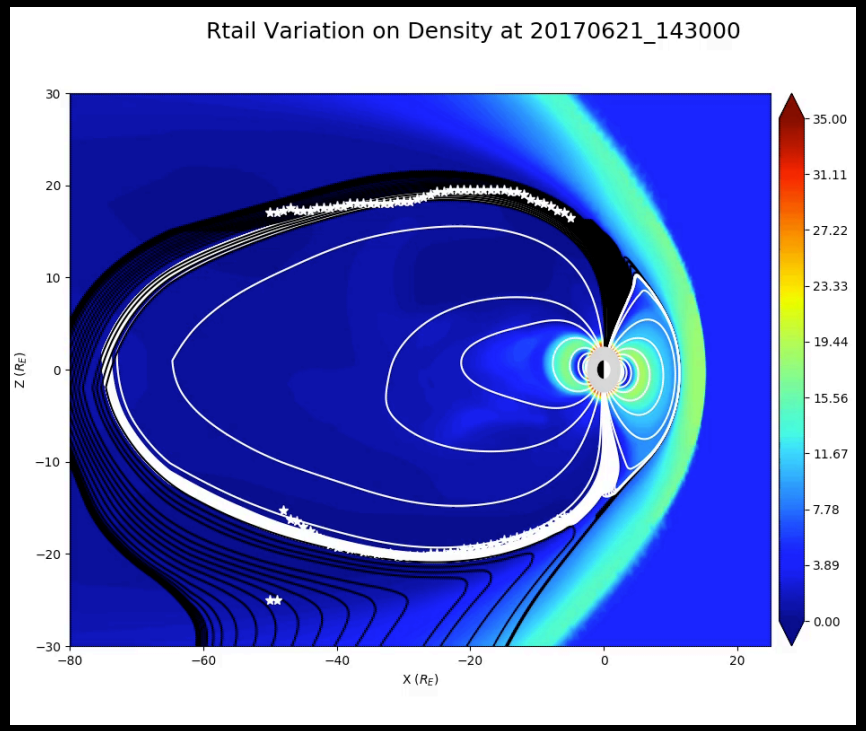
The nose compresses first, leading to Sunward flows in the dayside flanks.

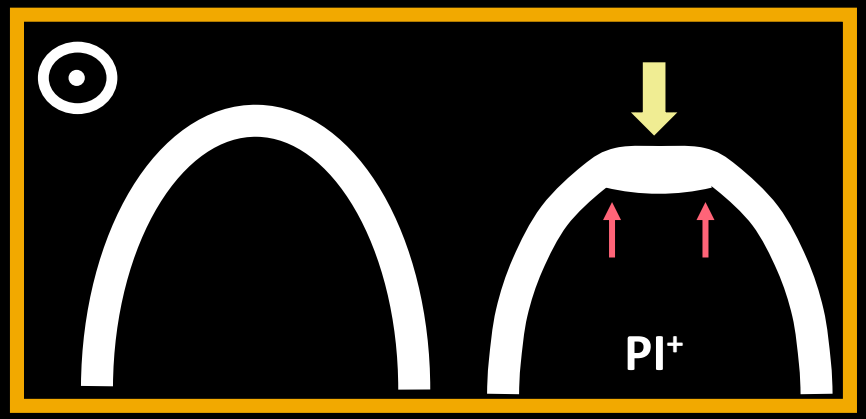
Vortices form in the dawn and dusk sectors.

<u>Drivers:</u>
Bz = 5 nT,
By = 0 nT,
Vx = 320 km/s,
n1 = 5 #/cm^3,
n2 = 50 #/cm^3,
P_2/P_1 = 8.4

BATS-R-US simulations

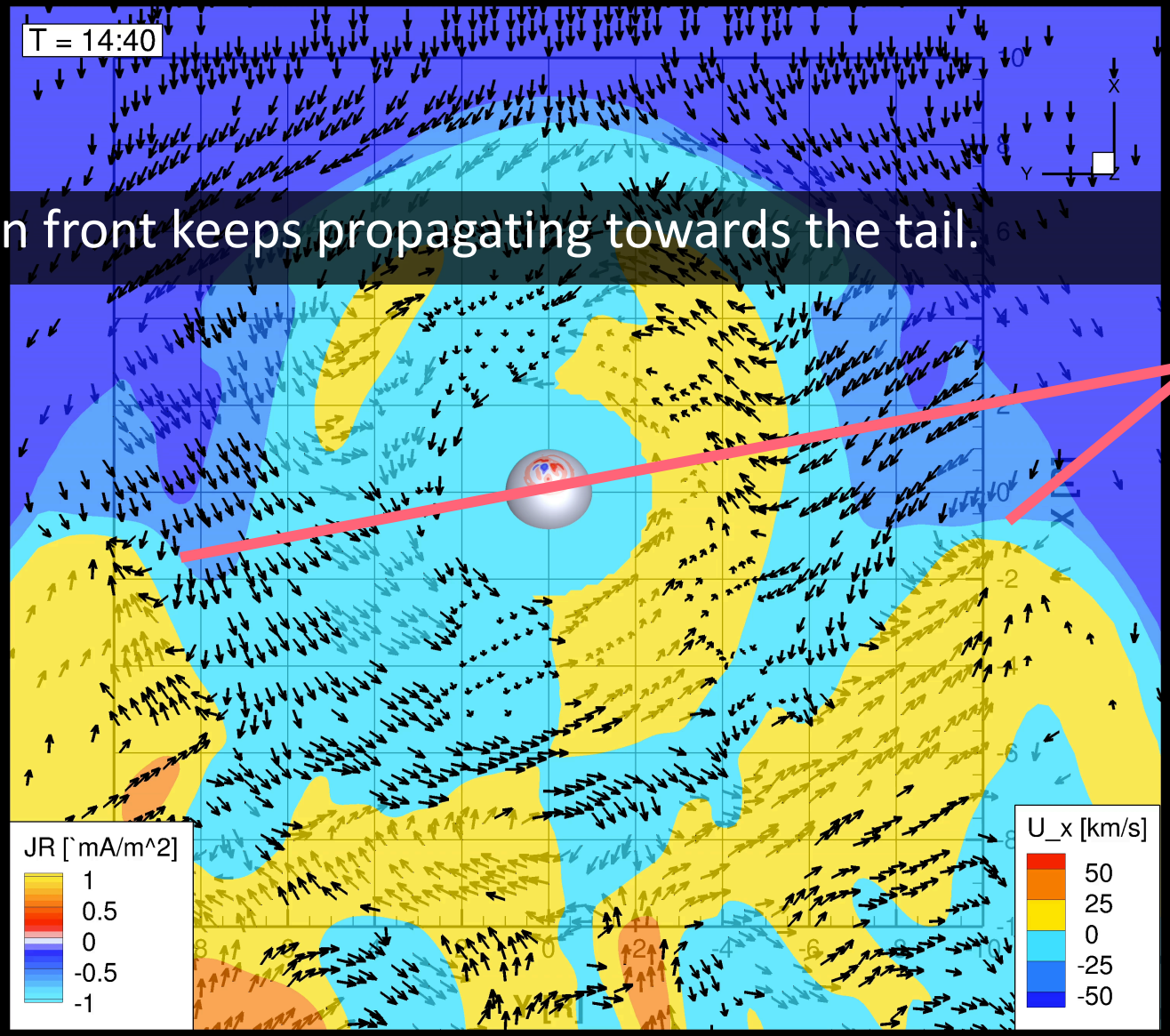






Sudden compression of the magnetosphere: 2. Main Perturbation

Compression front keeps propagating towards the tail.



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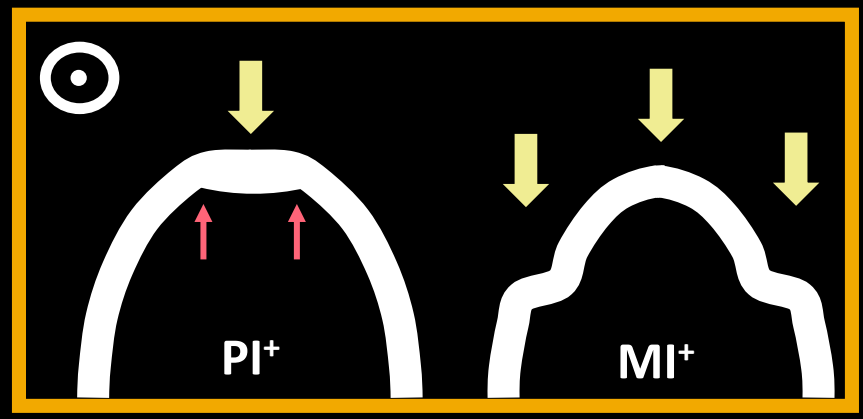
P_2/P_1 = 8.4

BATS-R-US simulations

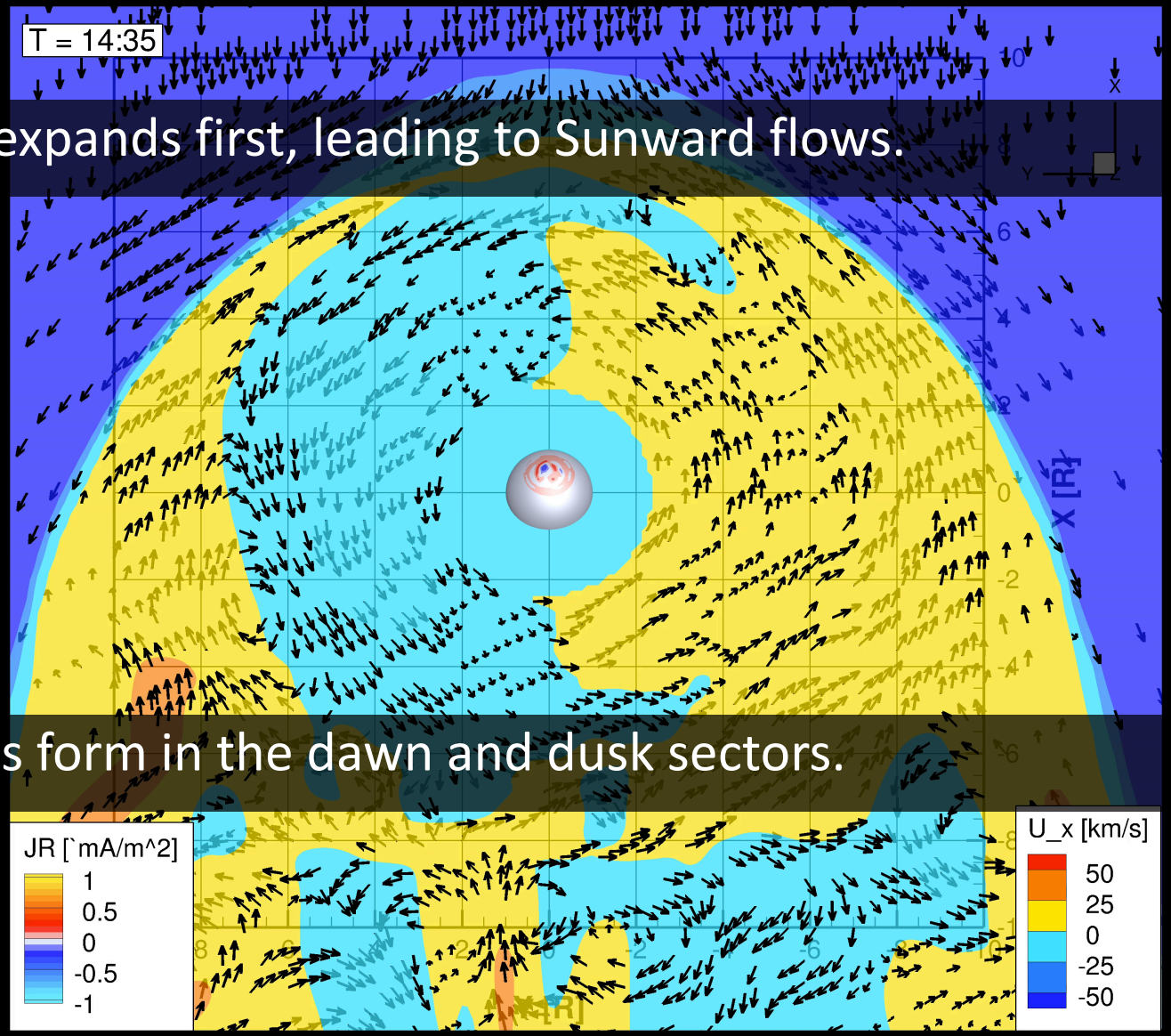
A new pair of vortices with opposite senses of rotation to those at the Preliminary Perturbation appears.



Sudden decompression of the magnetosphere: 1. Preliminary Perturbation

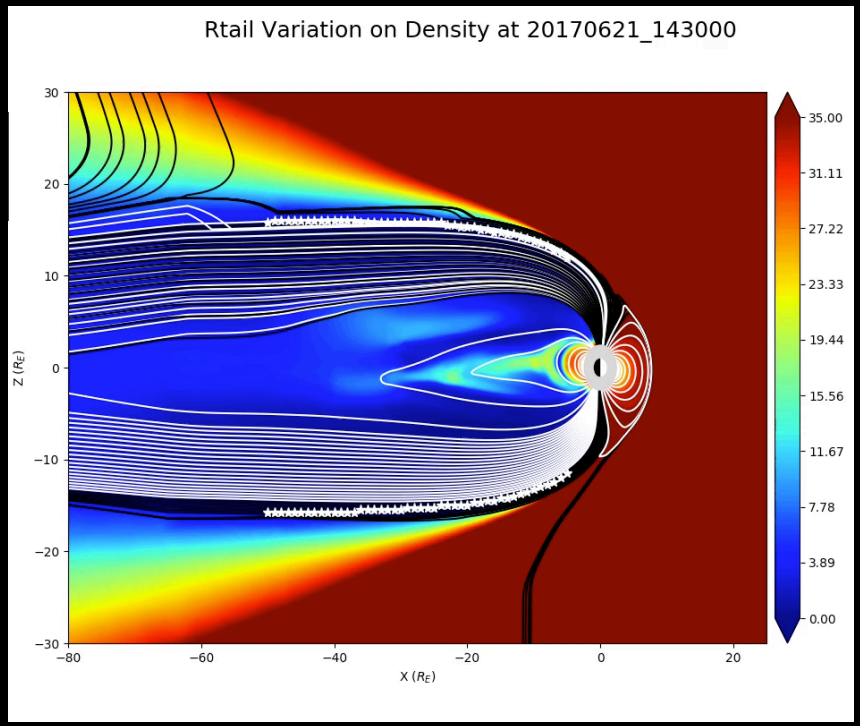
The nose expands first, leading to Sunward flows.

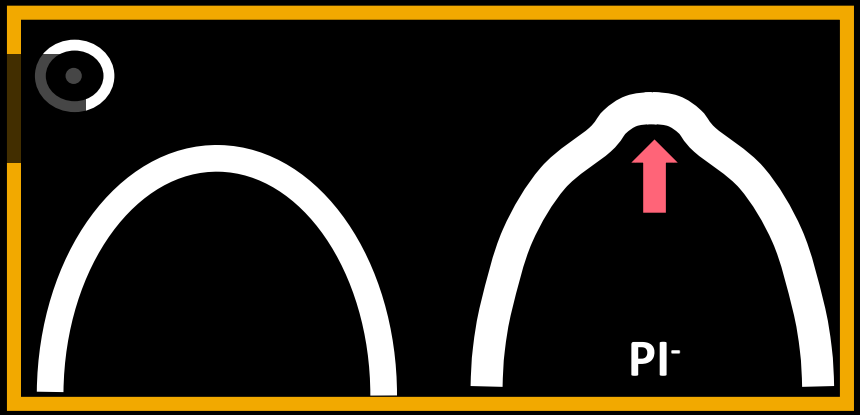
Drivers:
Bz = 5 nT,
By = 0 nT,
Vx = 320 km/s,
n1 = 50 #/cm^3,
n2 = 5 #/cm^3,
P_2/P_1 = 0.12



Vortices form in the dawn and dusk sectors.

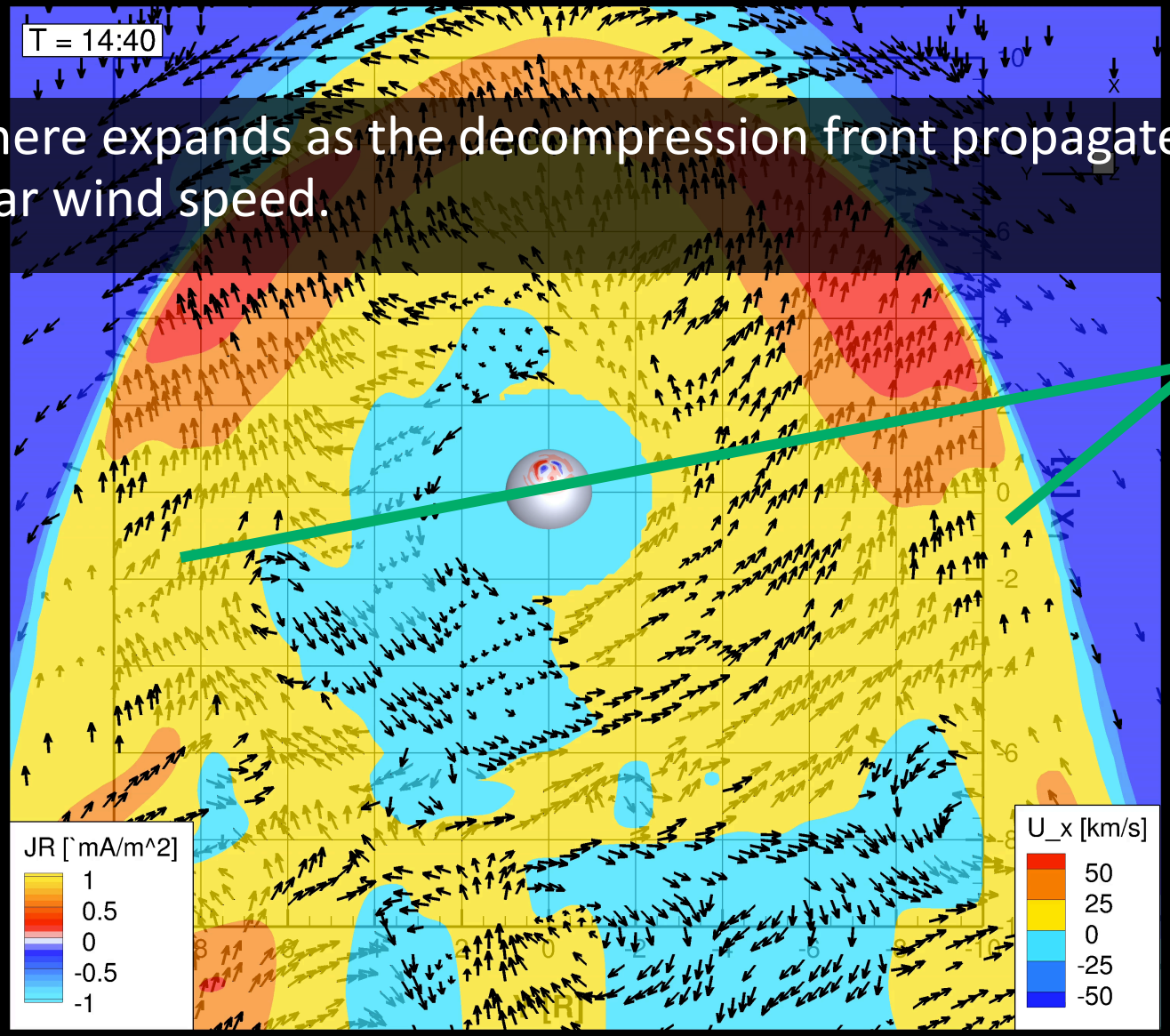
BATS-R-US simulations





Sudden decompression of the magnetosphere: 2. Main Perturbation

Magnetosphere expands as the decompression front propagates with the solar wind speed.



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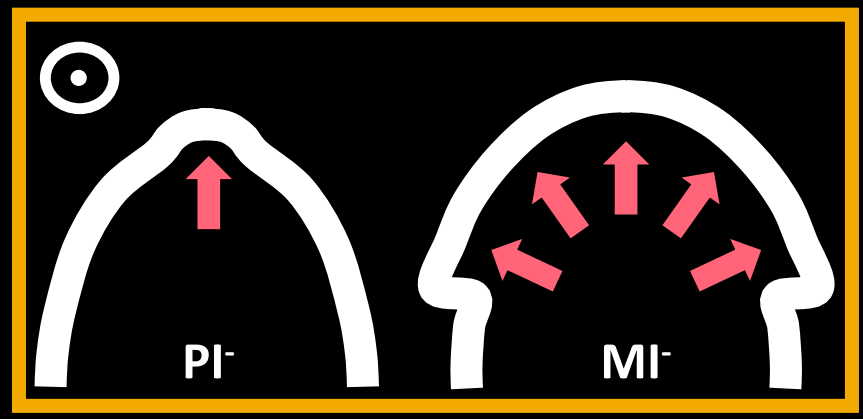
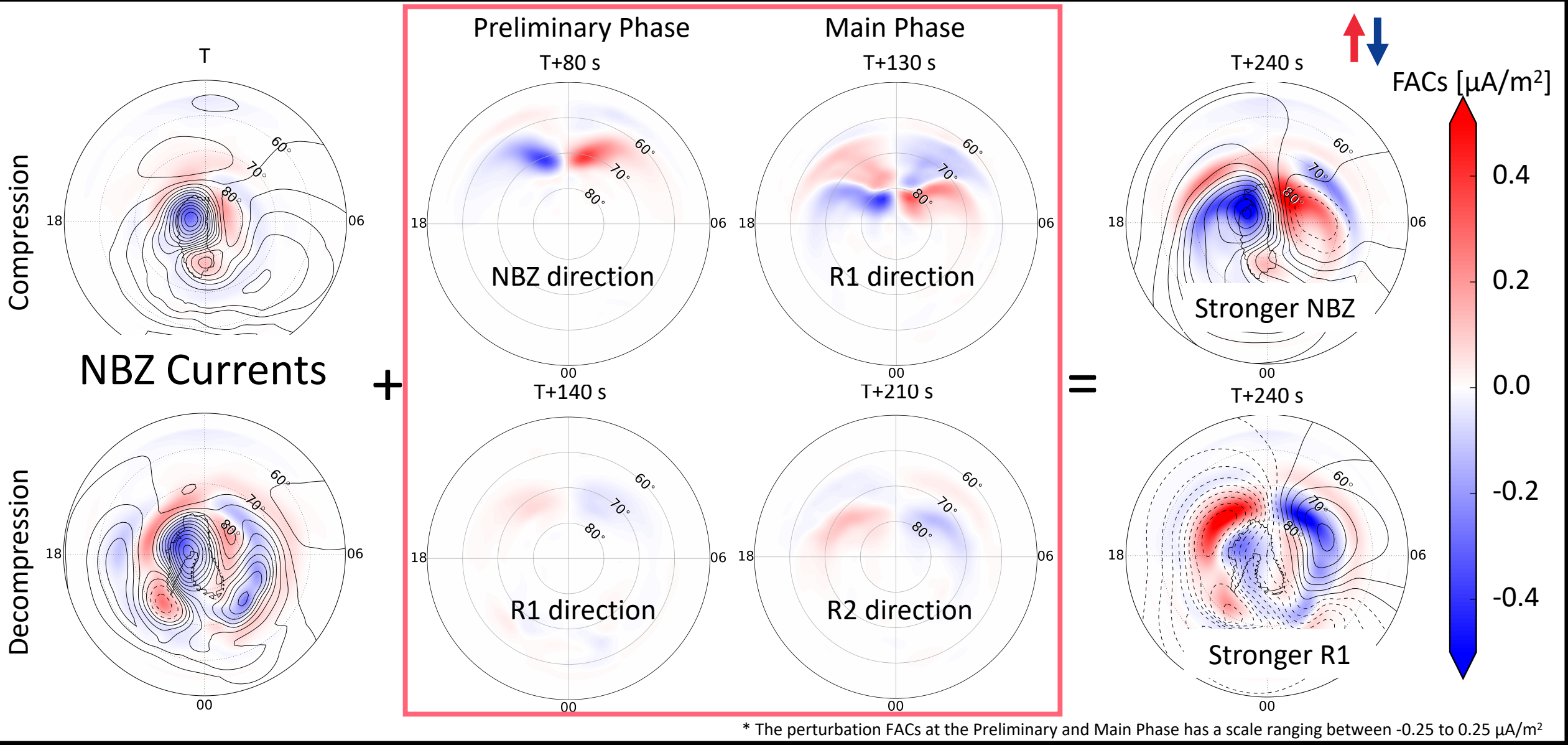


FAC response to sudden changes in the solar wind dynamic pressure



* The perturbation FACs at the Preliminary and Main Phase has a scale ranging between -0.25 to 0.25 μA/m²

Ion convection response to sudden changes in the solar wind dynamic pressure

<u>Compression:</u>

Highest temperature enhancements

(1) Between oppositely oriented Preliminary Phase FACs

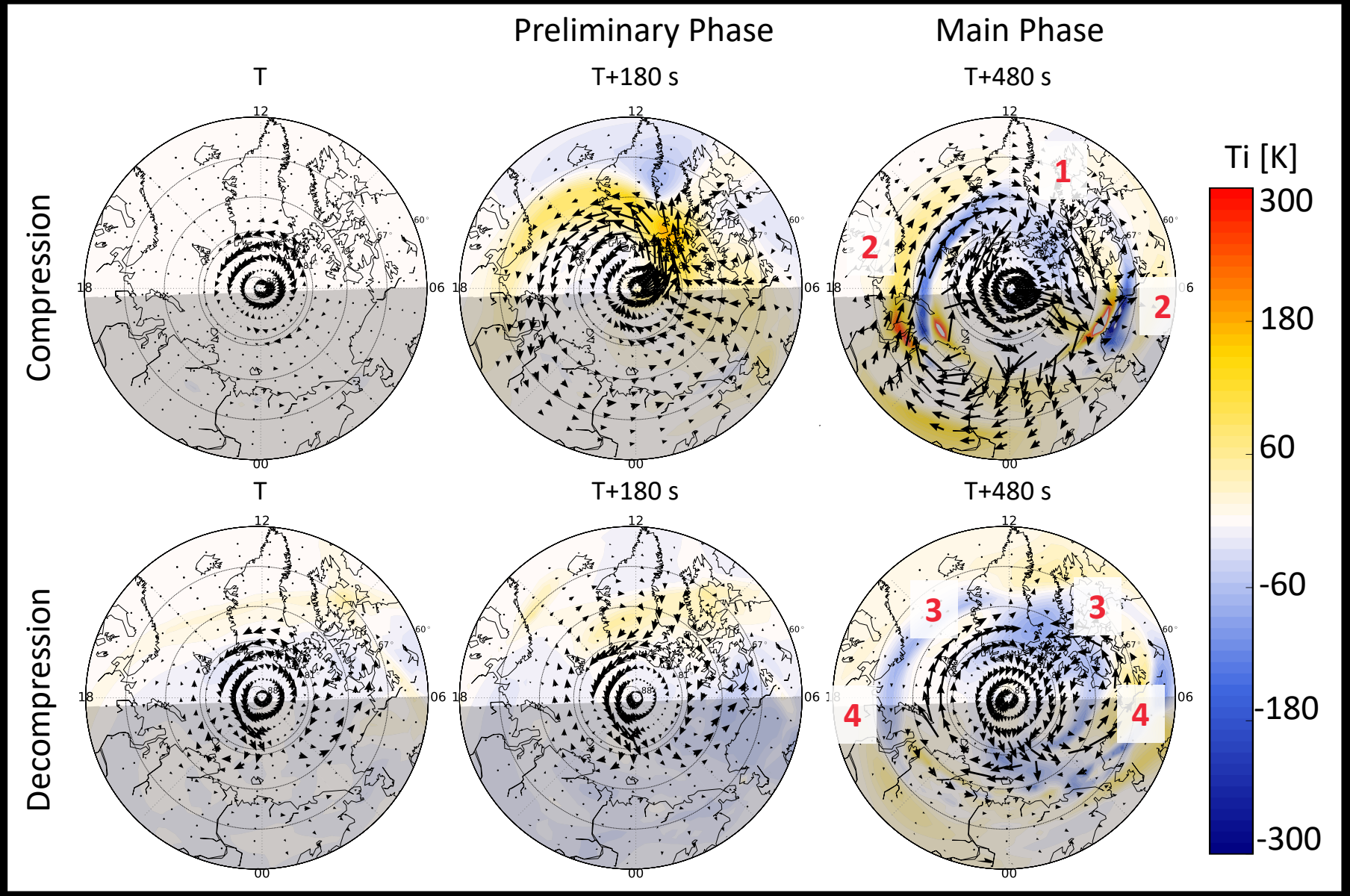
(2) Between Preliminary and Main Phase FACs

<u>Decompression:</u>

(3) Between Preliminary Phase FACs and NBZ currents

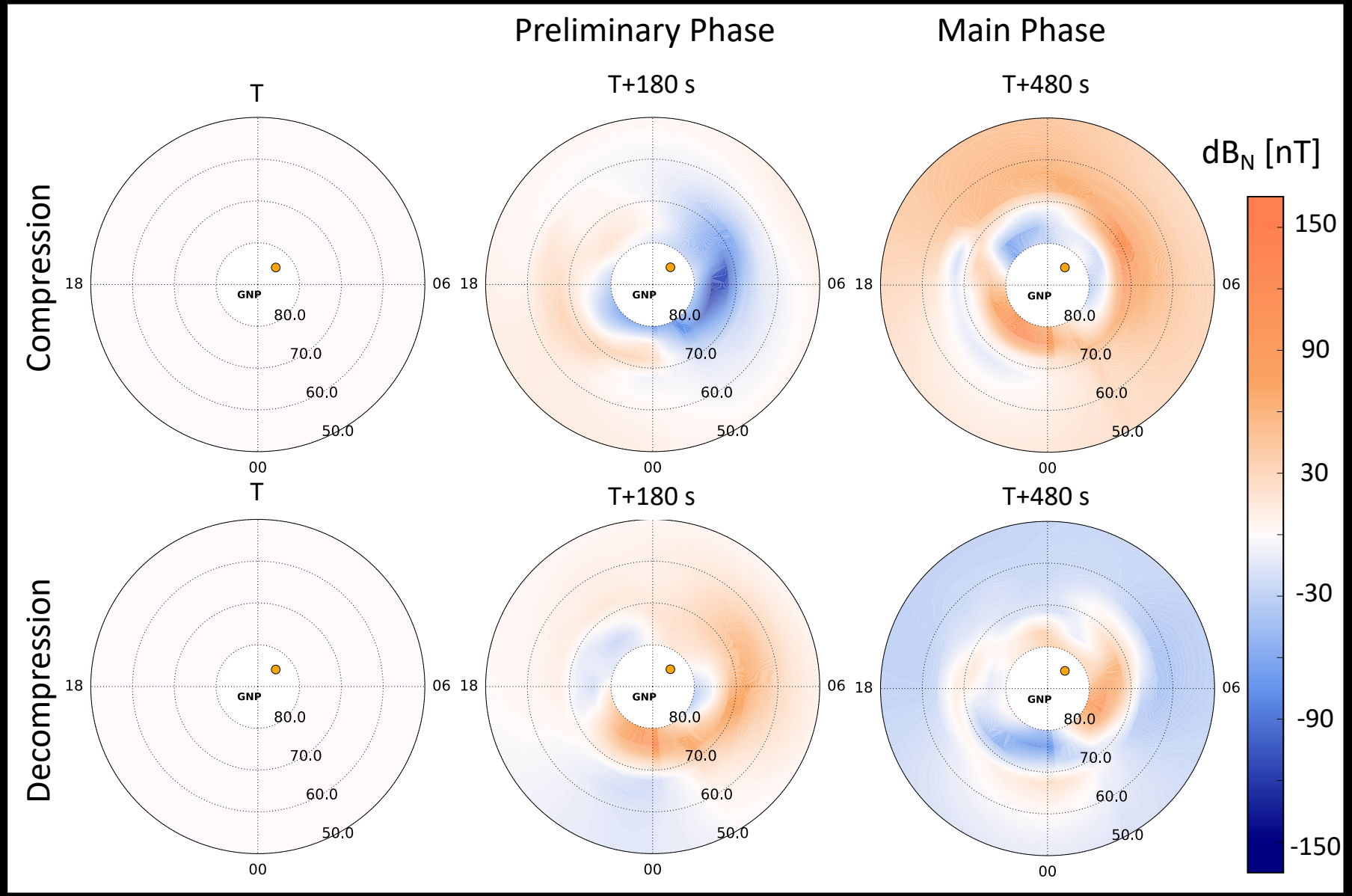
(4) Between Preliminary and Main Phase FACs

GITM simulations



Ground magnetometer response to sudden changes in the solar wind dynamic pressure

- Two-step response in both compression and decompression
- Dawn-dusk asymmetry
- Difference in high vs mid-latitude responses
- Slight deviations from Araki's mirror image model



BATS-R-US simulations

Solar wind dynamic pressure effects on the global M-I system

- The preliminary and main responses to a sudden increase and decrease of solar wind dynamic pressure are opposite to each other.
- M-I responses during the preliminary and main phases are opposite to each other.
- There is a prevalent dawn-dusk asymmetry between responses.

Event	Compression (SI^+)				Decompression (SI^-)			
Phase	PI^+		MI^+		PI^-		MI^-	
Location	dawn	dusk	dawn	dusk	dawn	dusk	dawn	dusk
M. Vortex	↻	↺	↺	↻	↺	↻	↻	↺
I. Vortex	↺	↻	↻	↺	↻	↺	↺	↻
FACs	↑	↓	↓	↑	↓	↑	↑	↓

- The overall response of the M-I-T system depends on the pre-existing magnetospheric flows and ionospheric currents systems.
- Araki's model successfully predicts the general trend of the ground magnetic field perturbation signatures

* The publication in preparation includes responses to weak compression and decompression as well as the variations in the I-T system.

Thank you for your interest.